Vegetal dissemination in the genus Opuntia.

J. W. TOUMEY.

The discussion here presented is based upon observations made during the past four years on the various species of Opuntia indigenous to Arizona. All of these plants, more especially the younger growth, are soft and fleshy, with large quantities of sap stored in the cortex and pith. No other plants so persistently retain their moisture when once secured. A thick epidermis with small sunken stomata and the evaporating surface brought down to a minimum, by the condensed form characteristic of the entire genus, enable them to remain green for months, even when continually exposed to the dry and scorching heat of our southwestern plains. They are alike at home on the plains and among the rocks of our mountains and foot-hills. Although of recent origin, compared with other large families of plants, they have lived for ages subjected to an environment which has placed them among the greatest economizers of water to be found in the entire vegetable kingdom. Not only are they economizers of water, but their tissues are, under ordinary circumstances, well provided with water, even after months of exposure to an average maximum temperature of 100° F. and untouched by dews or rains.

Much of the tissue entering into their composition, consists of large thin-walled parenchyma cells, which serve as store-houses of water. These cells have the power of taking up water with great avidity after and during a rain, or when the ground is moist, and as a result the young branches become plump, smooth, thicker, and the tubercles less prominent. As the days become warmer and the rains less frequent these cells gradually give up their contained moisture and the joints become withered and wrinkled. This process is, however, very slow, as many species remain green a year or even longer, after every source of outside moisture has been withdrawn.

The first of July, 1892, half of one of the flat joints of *Opuntia basilaris* was brought to my room and placed, without soil or moisture, in a small open box. The specimen was

three inches long, two inches wide and from one-half to two-thirds of an inch in thickness. On the tenth of the same month I observed a branch developing at one of the upper tubercles.

The specimen began to attract my attention and on weighing it I found it weighed 11.78^{gm}. The ten days intervening from the time the specimen was procured until it was weighed it undoubtedly lost considerable by evaporation. In the meantime, however, the large wound, caused by cutting the joint lengthwise had become practically impervious to evaporation by the exuding of the mucilaginous substance of the adjacent cells forming a thick scab-like crust over the wound.

The branch continued to grow rapidly while the old stem began to wither at the point farthest away from the branch. This process continued much in the same manner, month after month, during the entire summer. Not a single drop of moisture came in contact with it after it was placed in the box.

On the twentieth of January of the following year the specimen weighed 10.016^{gm}, losing in six months a little over fifteen per cent. of its total weight. At this time the branch had grown to be five and one-fourth inches long, or nearly twice the length of the old joint. It was, however, very slender and thin.

About seven-eighths of the old stem was dry and hard, but the portion immediately surrounding the base of the growing stem was as fresh and green as ever.

The next observation was on April fourth. At this time the specimen weighed 9.259^{gm}. The old stem was now entirely dry; the branch was nearly six inches long and as fresh as ever. By the middle of May the branch began to wither, but a new one had begun to develop about an inch from the apex of the other. By June twentieth, the new branch had grown to be two inches in length but was even now more slender than the first. In the six months from January to June, inclusive, the specimen had lost a little less than eight per cent. of its weight at the time of the first weighing. No further observations were made for a period of four months. On my return from the east in September the entire plant was dry.

The persistency with which cylindropuntias retain their

moisture is as marked as it is in the flat-stemmed forms. In October, 1893, a number of one-year-old stems of *Opuntia Bigelovii* were placed in an open box to dry. Eleven months later these specimens were somewhat shrivelled but on being cut open were found to contain considerable moisture. Of the twenty or more joints placed in the box, none developed branches, but each grew a number of roots, usually one from each of a score or more of tubercles at the base of the joint. Many of these roots were four inches long and remained green throughout the summer.

In December, 1893, a number of nearly mature fruits of *Opuntia fulgida* were collected and similarly placed in an open box. At the end of ten months they had all developed long roots from the small tubercles at the base of the fruit but were practically nearly as green as ever.

The persistency with which these plants retain their moisture makes vegetal dissemination possible. With many species it is not necessary that the detached joints be disseminated during the rainy season. If they chance to fall to the ground during the driest portion of the year their contained moisture is sufficient to enable them to put forth roots which soon firmly anchor them to the ground, and a new plant is the result.

The opuntias of Arizona belong to the two sub-genera, Platopuntia and Cylindropuntia. With few exceptions the former are, in habit of growth, prostrate or at most only semi-erect, while the latter are nearly all erect. Both agree in having bristles and usually spines, which in many species are numerous and highly developed. The bristles are always barbed and are usually more numerous and more highly developed in Platopuntia. The spines in the two sub-genera differ in that in Platopuntia they are but slightly barbed, while in Cylindropuntia the barbed character of the spines is very pronounced. Morphologically the bristles and spines are the same; little is known, however, in regard to their functions.

As pointed out by Dr. W. F. Ganong,[1] it has been frequently asserted that the function of the spines is largely for protection and that the readily detached and irritable bristles serve the same purpose. There is no question but

[1] Present problems in anatomy, morphology and biology of the Cactaceæ. Botanical Gazette **20:** 129. 1895.

the spines do serve largely to protect these succulent plants from the ravages of animals. If they were not so protected, in a few years they would entirely disappear from our western plains. Another important function, more especially in Cylindropuntia, is their great aid in dissemination.

It is not sufficient that the joints grow when detached from the parent plant. They must find a means of transportation from one place to another. In cylindropuntias this is largely effected by means of the barbed spines which adhere closely to all objects which come in contact with them.

As previously stated the spines of Platopuntia are nearly smooth or but slightly barbed, but with these plants barbed spines are not necessary to effect transportation; they are disseminated in an entirely different manner.

The species of Platopuntia being mostly prostrate or semi-prostrate, spread out with growth, forming large oval or circular patches. The branches creeping or bending to the ground take root at each joint. In the course of time, the original plant dying, the several branches become independent plants. This process is repeated until the product of a single plant may extend over a large area. Among specimens of *Opuntia pheacantha* growing a few miles east of Tucson I have traced nearly twenty plants to a common center, some of them being several rods distant. As a rule a dozen or more plants, in the immediate vicinity, indicate that they are the product of a single plant. Usually it is not difficult to locate the position of the original plant long after every vestige of it has disappeared. I am convinced that nearly all of our flat-stemmed opuntias are disseminated in this manner. It does not apply of course to the few upright forms like *Opuntia chlorotica.* Although these upright forms are not disseminated in the same way as the prostrate plants, vegetal dissemination is not entirely eliminated. The young joints of the upright species are much more easily detached than in the prostrate species. Cattle and other animals feed to some extent upon them. From one cause or another many of the joints are broken off. The spines, although but slightly barbed, are of some aid in dissemination. They raise the detached stems from the ground so that they are more easily disturbed by animals or other moving objects coming in contact with them and they are scattered further from the parent plant than they would be if devoid of spines.

In a recent observation on *Opuntia chlorotica* growing at Steins Pass, N. M., detached joints were found, at least two rods from the plant upon which they grew. They were all firmly anchored by long roots penetrating the ground from under side of the joint.

It is with the cylindrical opuntias, however, that the spines have an important part to play in vegetal dissemination. Nearly all of this large group depend almost entirely for dissemination upon the readiness with which the terminal branches break off and upon the highly developed barbed spines which cover them.

One of the species best adapted for dissemination is *Opuntia Bigelovii*, a plant abundant on the mountains and foot-hills of south-central Arizona. The tubercles are crowded and the pulvilli are covered with numerous, radiating, highly barbed spines. These formidable spines are so numerous that they completely hide the epidermis of the plant. Although the joints are from two to five inches long and more than an inch in diameter, the point of union with the old stem is very slight, the scar left at the place of detachment being but two or three lines in diameter. The slightest touch will detach the young joints and they cling as formidable burrs to any object with which they come in contact. It is not an unusual sight on the Arizona plains, to see cattle with scores of these burrs firmly fastened to their legs and head. They are sometimes carried for miles and when finally detached, even after weeks of travel, are in condition to grow. This plant depends so completely upon this method of dissemination that it has almost entirely lost the power of seed-production. In fifty fruits examined last fall, but two perfect seeds were found. Forty-eight of the fruits were sterile and the other two had but one perfect seed in each.

Of the fourteen species of Cylindropuntia which I have examined in the field, all are more or less adapted for dissemination in this manner. Some species, such as *Opuntia Bigelovii*, *O. fulgida*, *O. mamillata*, *O. echinocarpa* and *O. prolifera*, are exceptionally well adapted for this method of dissemination; the joints are easily detached and are well armed with strong barbed spines.

The fruits of the larger number of the above species are seldom sterile but the seeds are small, and in our unfavorable climate, seldom germinate. Among the thousands of speci-

mens of Opuntia Bigelovii and Opuntia fulgida that have come under my observation, I have never as yet seen a single seedling developed under natural conditions. The ground in the vicinity is strewn with numerous detached joints, all capable of becoming new plants.

In some of the smaller species, as *Opuntia leptocaulis*, *O. tessellata*, and *O. arbuscula*, numerous short, lateral joints are developed; which, although small, retain their moisture for a long time after being detached. Evidently the function of these small, easily detached joints, is for vegetal dissemination. The fruits of two of these plants, viz. O. tessellata and O. arbuscula, are usually sterile.

Opuntia arborescens, *O. Whipplei*, *O. versicolor* and similar species are not so well adapted for this method of dissemination. With these plants the joints are not readily detached and the spines are not so strongly barbed; they depend to a much greater extent upon seed dissemination, as is illustrated in the fact that it is not an unusual thing to find seedlings of these plants in all stages of development.

As a generalization it may be stated that with this great group of plants the adaptations for vegetal dissemination are inversely as their seed production.

University of Arizona, Tucson.